SURVEYING FOR INSPECTORS
Day 1

INTRODUCTION

- The purpose of this class is to give you exposure to basic surveying terminology, equipment, tools, and calculations related to the needs of construction inspection.

- Some of what you will hear in this class will be a repeat of your Plan Reading course and we will be working with the same set of highway plans used in that class.

- As an inspector you will be relating and comparing proposed (plan) information to horizontal and vertical locations in the field. This will require you to have a thorough understanding of the plans, be able to check survey stakes or actual construction, and determine accuracy relative to the proposed information.

- As an inspector you will NOT be required to do the surveyor’s job. Therefore much of what is taught in a traditional “introductory surveying class” will not be a concern to us at this time.

OBJECTIVES

- By the end of these two days of instruction, you will be expected to have the basic tools needed to accomplish the following:
  - Interpret proposed information from plans.
  - Check field location of survey stakes and actual construction features.
  - Obtain and calculate field measurements.
  - Communicate with contractors/engineers & surveyors/inspectors.
- Your **goals** to achieve in this class will be:
  - Recognize and be able to use basic survey instruments and equipment.
  - Understand how to read and measure distances.
  - Understand how to read and interpret survey stakes.
  - Prepare legible field notes.
  - Compute and check elevations.

TERMINOLOGY & DEFINITIONS

Horizontal curve- a portion of a circle (arc) connecting two tangent lines of the horizontal alignment of a roadway in consideration of design speed, topographic features, economy and other variables.

Height of Instrument- In trigonometric leveling, the height of the line of sight of a total station instrument above the point it is set over.

Height of Rod- In trigonometric leveling, the height of a prism pole measured from the bottom end of the pole to the center of the prism.

Horizontal control- The network of control for a project area that has accurately known northing and easting coordinates

Horizontal distance- the distance measured in the horizontal plane, either directly or a distance computed from a slope distance.

Invert- The elevation of the bottom of a structure or the low point on the inside of a pipe.

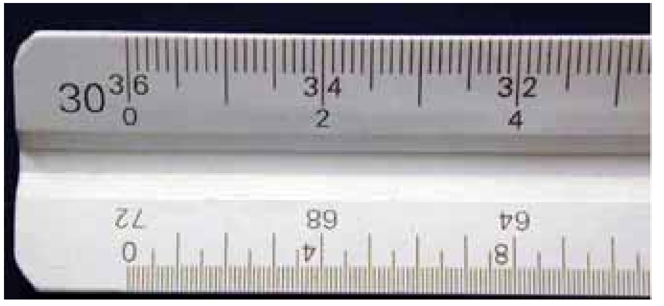
As we progress through this class, you will be hearing terms that you may not be familiar with. We will discuss some of them; but included in your hand-out, behind Tab 3, is Appendix A, which is a glossary of terms relevant to surveying for construction projects. You may find this to be a helpful reference as you progress into your OJT.

TERMINOLOGY & DEFINITIONS

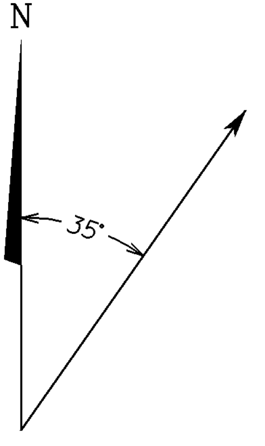
- Boot: difference between the HI and the actual rod height.
- Break chain: if the distance you want to measure can't be measured horizontally without sloping the tape, than you need to break chain and set a break point for the rear chainman to re-position to continue chaining.
- Catch: point that slope intercepts original ground. Could be a in a cut or fill section.

MEASUREMENTS

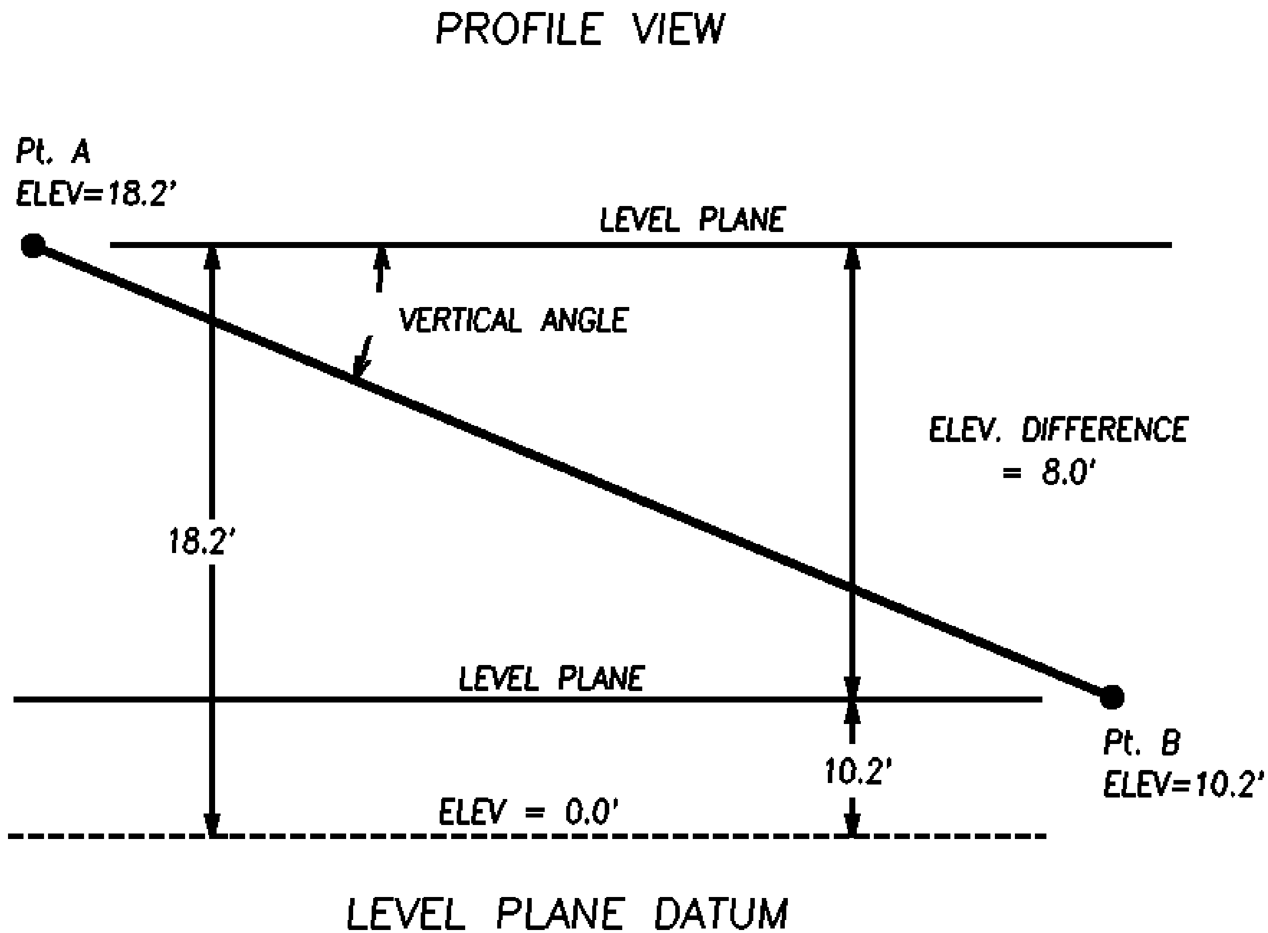
Three distinct types of measurements are utilized by the surveyor to define the relationship of points.



- **Horizontal Distance:** distance between two points as measured on a horizontal or level plane.

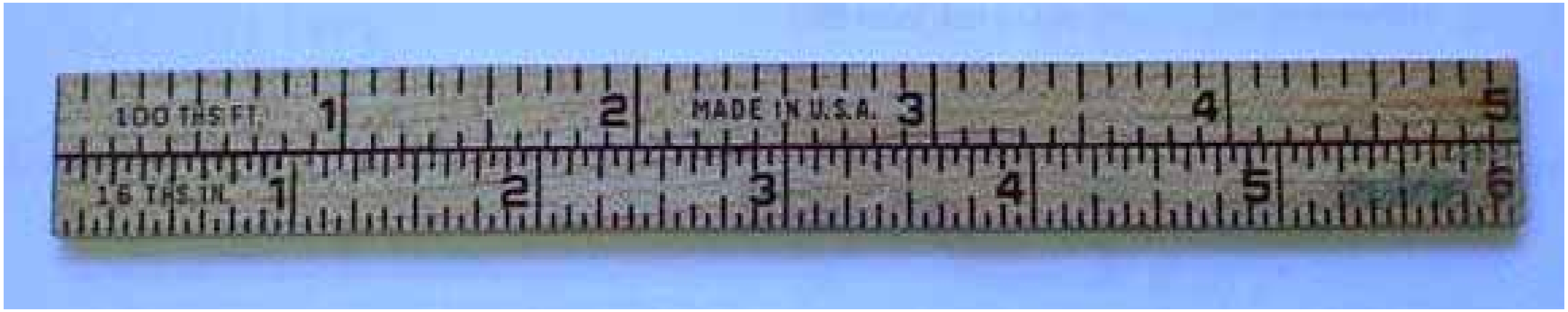


- **Direction:** angles measured in either horizontal or vertical plane.



- **Elevation**: vertical difference between two points, relative to a **datum**.

Units of Measurements



- English: feet, miles, acres
- Metric: meter, kilometer, hectares

- Surveyors use the **decimal** foot as opposed to the builder's or architectural standard of 1/16ths. Surveyors' tapes, rules, level rods, etc. are based on a foot being divided into ten parts or tenths of a foot (0.10'). A tenth of a foot is further divided into ten parts or hundredths of a foot (0.01'). So a measurement is shown as 25.16'.
- Angles are measured by **degrees**, **minutes**, and **seconds** being shown as 15º 20' 35"
- **Acreage** is measured in square feet. An acre equals 43,560 s.f. which is approximately 210' x 210'.

Accuracy, Precision, and Positional Tolerance

The terms accuracy and precision are often used interchangeably to describe the correctness of a measurement. This is incorrect because these two terms have different meanings.

- **Accuracy** relates to how close a measurement is to the true value.

- **Precision** is a measure of consistency and how close measurements are to each other.
  Both are equally important in the surveyor's field work.

- **Tolerance** can be defined as how much a field measurement or point set in the field can vary from the true angle, distance, or location. Tolerances vary based on the type of work being performed.

  For example, a tighter or higher tolerance is required for bridge stakeout than the stakeout of a ditch. To determine the level of tolerance, you must consider several factors such as:

  - **What is the desired end-product and will a variation impact it's function?** For example, a horizontal shift in a culvert alignment does not impact the pavement surface.

  - **What material is being used in the construction?** For example, a rip-rap lined drainage ditch (low tolerance) versus a concrete bridge abutment (high tolerance).

  - **How will the item be constructed, and of what accuracy is the construction equipment capable?** For example, a bulldozer has low tolerance (within a few inches), while a curb and gutter machine has a high tolerance (within a quarter of an inch).

Accuracy and Precision

Accuracy- the degree of perfection obtained in measurements

Precision- the closeness of one measurement to another

By studying these definitions one will find that it is possible to have precision without accuracy and vice versa. Consider the following: a distance is measured three times and the values of 92.72ft, 92.69ft, and 92.71ft are recorded. The values are precise and appear to be accurate. However, if it were found that the tape used was not 100ft long but 100.3ft in length then the measurements would not be accurate even though they are precise. This idea is illustrated in Figure 1.

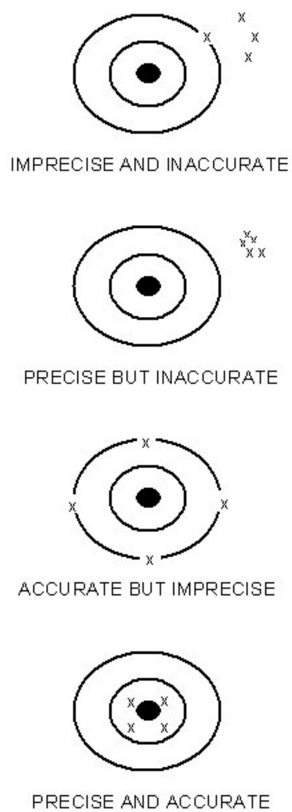


Figure 1: Accuracy vs. Precision

MEASUREMENTS

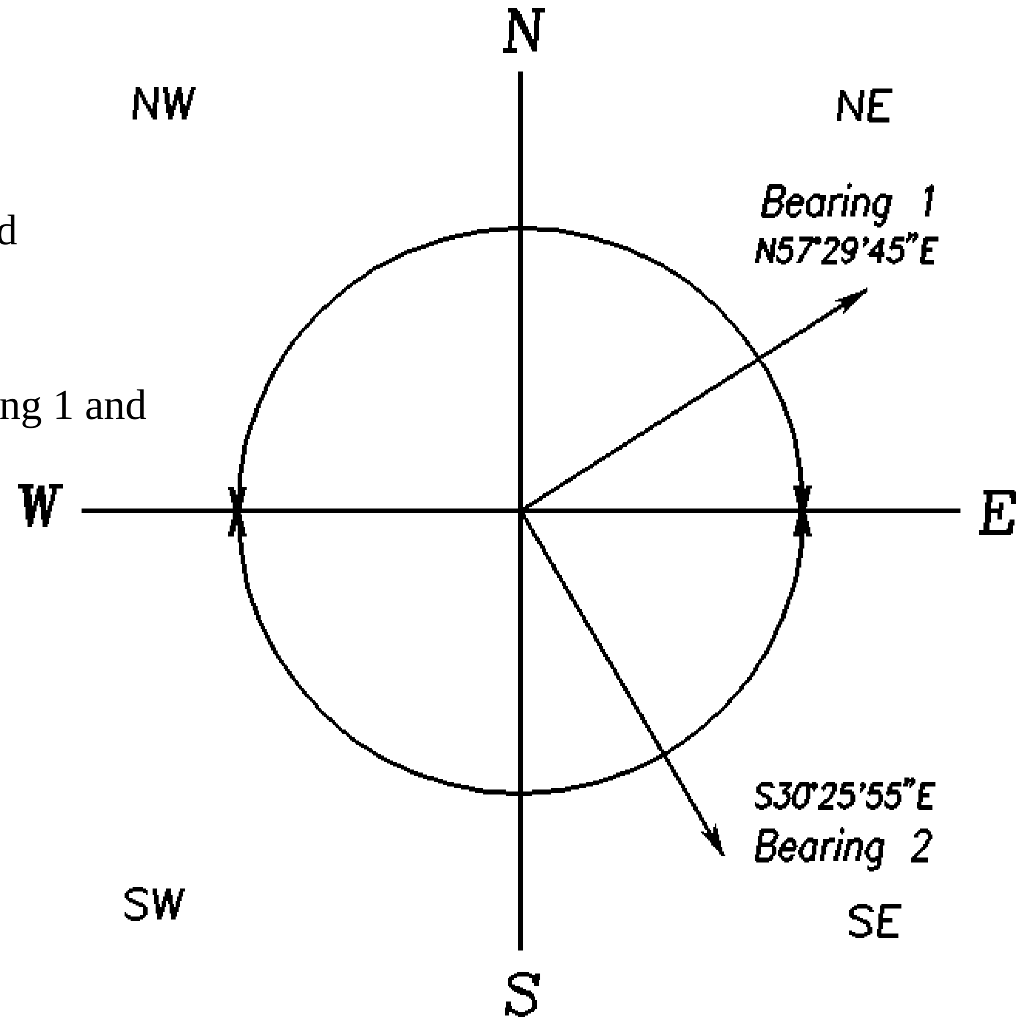
Horizontal Angles & Bearings

- Circle-360°
- Quadrants- NE SE SW NW
- Adding & Subtracting angles and bearings

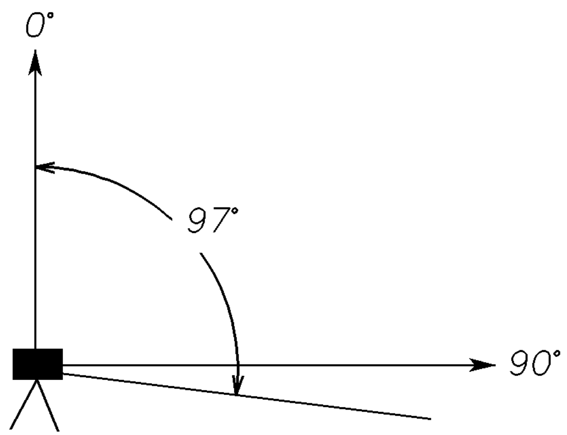
What is the angle between Bearing 1 and Bearing 2?

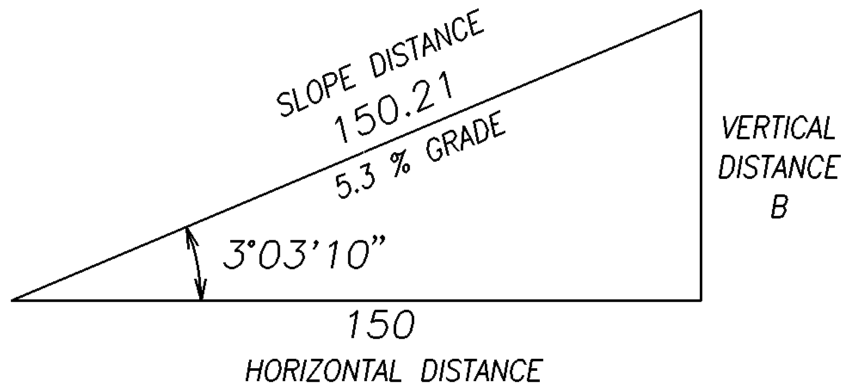
N57°29’45”E
<u>S30°25’55”E</u>
87°54’100”-60
= 87°55’40”

= 179°59’60”
87°55’40”
= 92°04’20”



Vertical Angles and Slope Distances



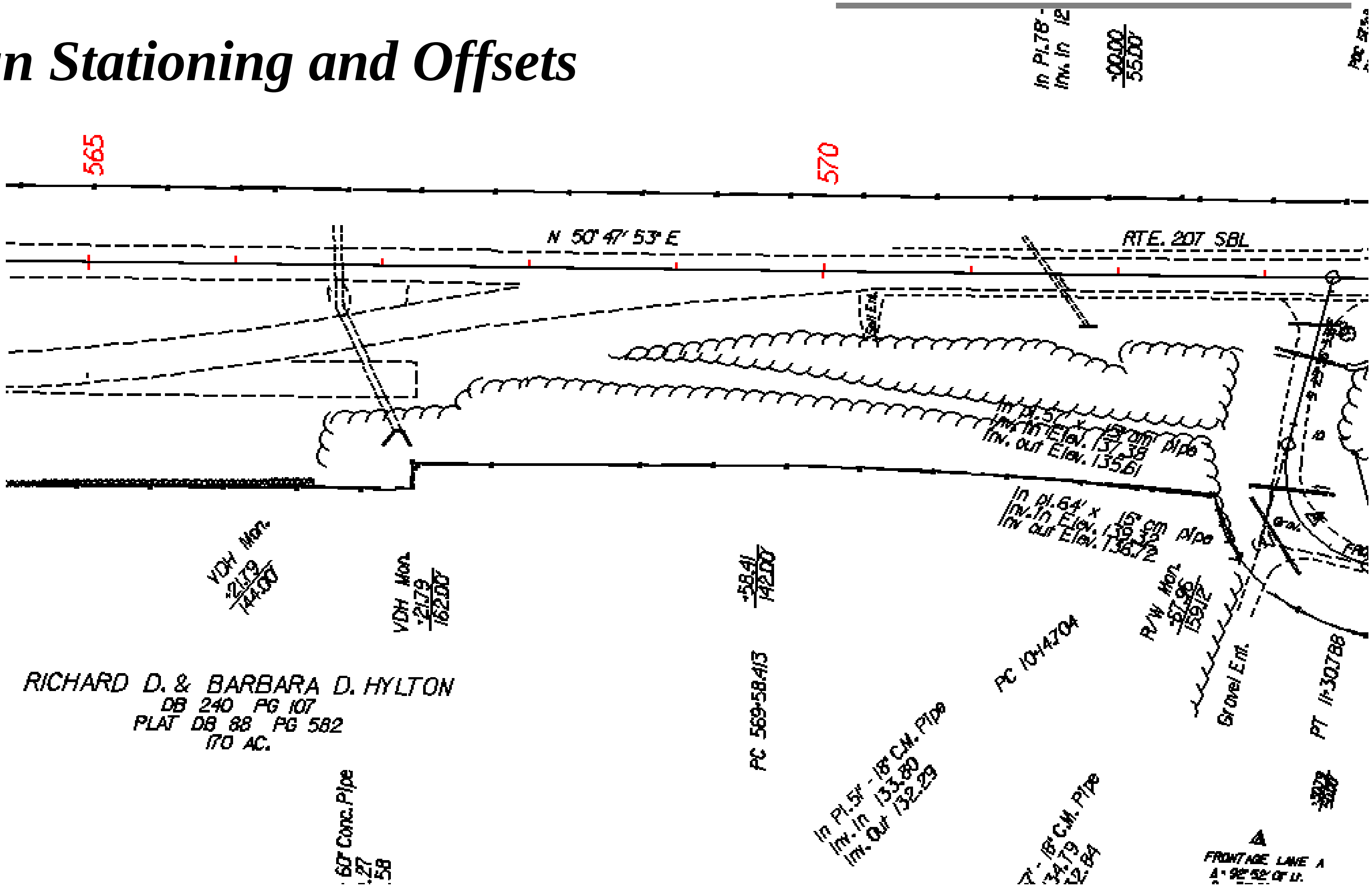


- **Vertical angles** are measured by a **theodolite or total station.**
- **Slope distance** is the distance measured along the inclined surface.
- % of Grade is "the degree of inclination from the horizontal, the rise or fall for each 100 feet measured horizontally."*

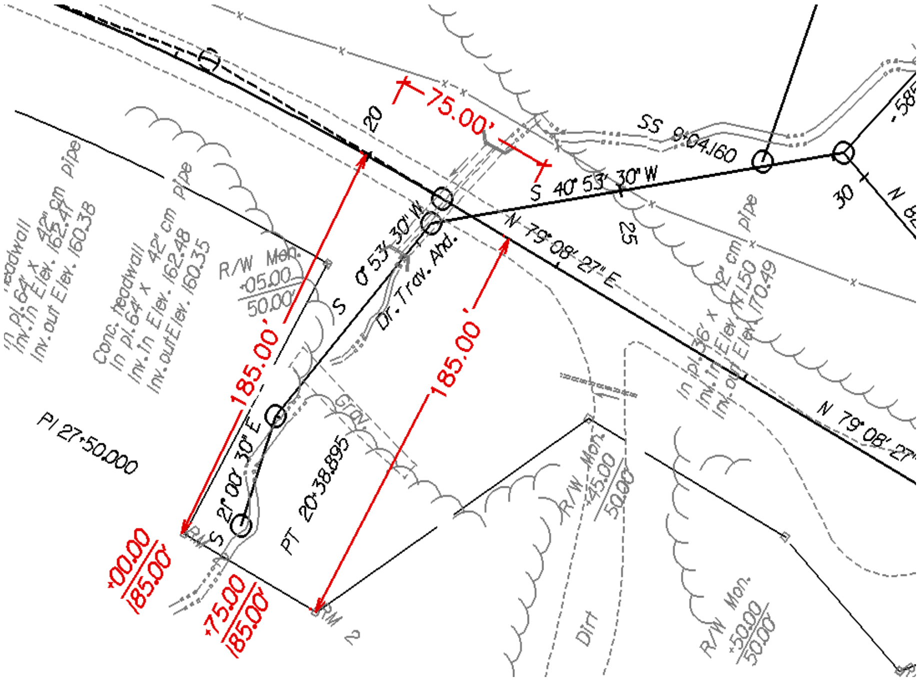
  example: 3% grade = 3' rise or fall in 100'

* from Plane Surveying by John C. Tracy, C.E.; Yale University, 1907

Plan Stationing and Offsets



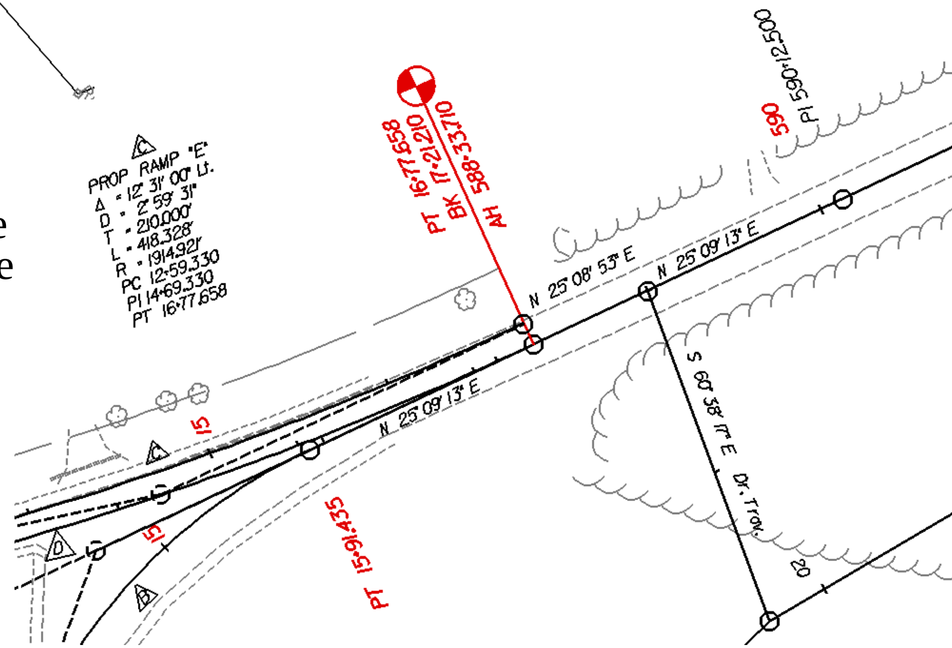
- **Stationing** is used to define distances relative to the alignment of the roadway. 100 foot stations are marked on the horizontal alignment by ½ tick marks at the 100' intervals and full tick marks every 500'. A station is expressed as the 100' station followed by the remaining horizontal distance, ex. (566+70.25).



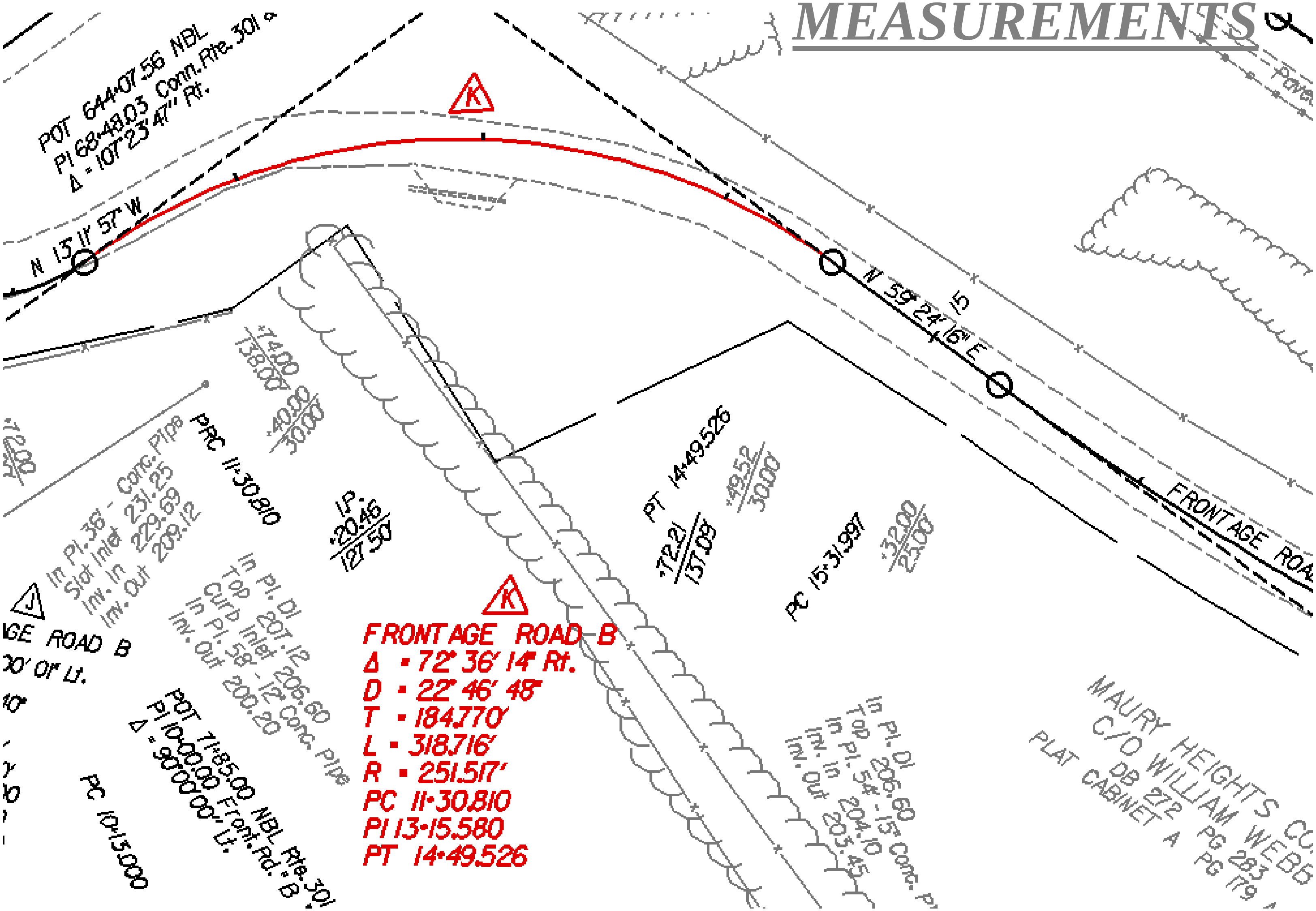
MEASUREMENTS

- An **offset** is given in order to relate points off of the construction baseline. Drainage structures, right-of-way breaks, and any other feature that the surveyor will have to stake in the field is referenced with a station and offset.

- Station **equalities** are used in cases where it is necessary to relate to another baseline in order to maintain the integrity of the information on both sets of plans. When calculations are performed involving points on either side of an equality, the value of the equality must be taken into consideration.



MEASUREMENTS



- Stationing on **circular curves** requires some basic understanding of the geometry of curves.

INTRODUCTION TO FIELD EQUIPMENT

Morning class was an introduction into the basics that surveyors use in the course of doing their work. We are now going to look at the tools and supplies used on a construction site.

Basic Surveying Equipment

Plumb Bob

- Probably the most common and well known survey tool is the **plumb bob**. A plumb bob is used, while taping distances, to project a vertical line from a point on the ground. While it appears to be as basic a tool as there is, skill and experience are required to use a plumb bob accurately and effectively. A Gammon reel is often used for storage of the string line which is attached. A plumb bob should be dried and wiped clean before storing it in its leather sheath.

Tapes

- There are many types and styles of tapes that you may see on a construction project. Most surveyors will have an accurate **steel tape** for use in setting out stakes. These tapes are usually found in 100’ or 200’ lengths and require the proper tension for accurate measurements.

- **Fiberglass cloth tapes** are common for making measurements where tolerances are low or rough checking distances. These tapes are relatively inexpensive and are easy to carry around a job site.

- **Stick rules** are handy for measuring short distances (under six feet) and fold conveniently to fit in a pocket or pouch. The engineers stick rule is graduated on one side in tenths of a foot while the other side is marked in inches. Care must be taken to be sure you are reading the correct side of the rule.

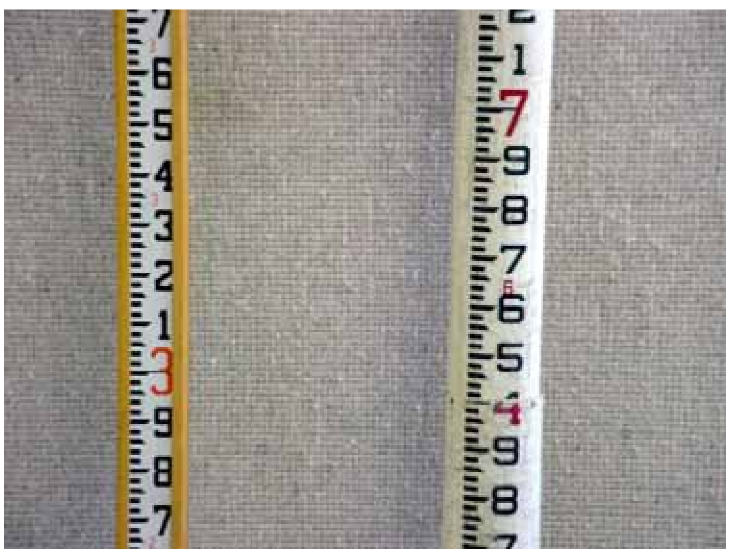
- With any measuring tape it is wise to check the graduations, prior to measuring, to assure accurate readings. It is important that tapes are held horizontal while measuring distances. If unable to hold the tape horizontal, a slope angle must be obtained and the horizontal distance calculated.

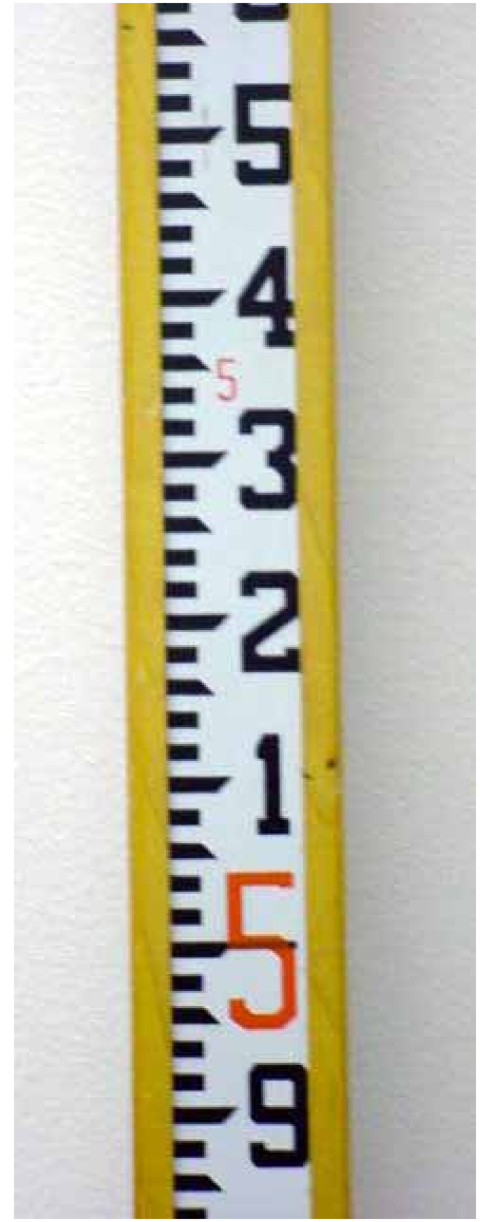
- Care should be taken with any tape to keep them clean and in the case of steel tapes, oiled. Tapes should be reeled up and not left out in roads or work areas.

Level Rods

- **Level rods** are available in various lengths, shapes, materials, and graduations. They are used for determining relative elevations in combination with auto or hand levels. Probably the most useful on construction projects will be the fiberglass extension rods which are available up to 25', but retract to 5'. These rods are available in metric and English graduations.

  Care should be taken to avoid damaging the face of the rod.





Tripod

- A **tripod**, as its name implies, is a 3-legged unit that is used for the stable set-up of survey instruments and targets. Instruments are locked onto the tripod by a lockdown screw attached to the head. Care should always be taken that the feet are firmly planted in the ground or weighted when set on pavement or concrete. Care should always be taken that the instrument is properly seated and locked onto the tripod.
- The head of the tripod should be kept clean and protected from damage. Tripods should be dried before storing in a secure and dry location (not thrown in the back of a pick-up truck).

Basic Surveying Equipment

Stakes & Nails

- **Wooden stakes** are found on any construction project. They are available in various lengths and widths, and are usually cut from pine or oak. The important thing to know about stakes is the labeling or marking that is written on them. This will be discussed in detail tomorrow.
- Surveyors also will use wooden hubs with tacks, iron rods or pipes, and nails (PK nails) for marking important points on the ground. Stakes may be used to reference these points and label the station or description of the accurate point set nearby.

Total Station 1150

A total station incorporates an electronic or digital theodolite, an electronic distance measurer (EDM) and a microprocessor in the same unit. Total stations can automatically measure horizontal and vertical angles as well as slope distances from a single setup. From this data they can instantaneously compute horizontal and vertical distance components, elevations and coordinates, and display the results on an LCD screen. They can also store the data either on board or in external date collectors. From the total station, data can be downloaded to a personal computer.

Theodolite

Transits and theodolites are fundamentally the same. Their most important application is measuring horizontal and vertical angles, but they can also be used to obtain horizontal distances and determine elevations. Transits and theodolites can be used for surveying applications when used with a calibrated taping chain or an electronic distance measurer.

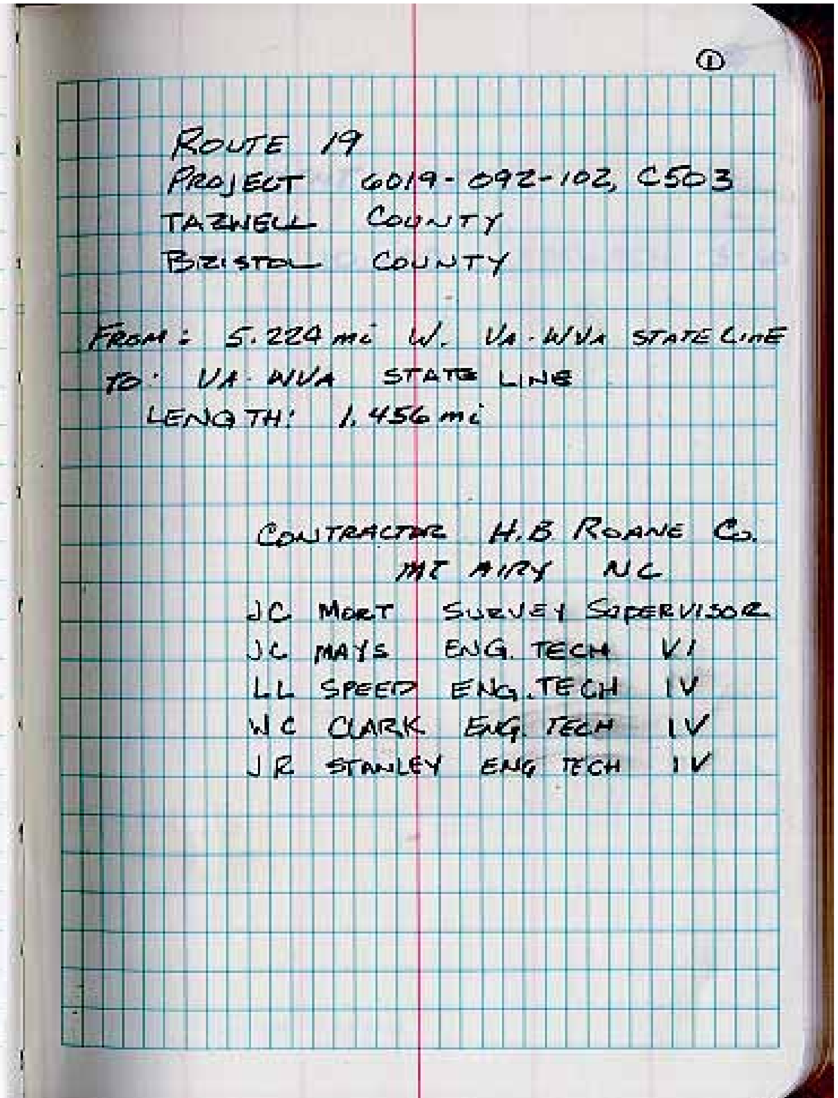
Figure 15: Theodolite

Automatic Level

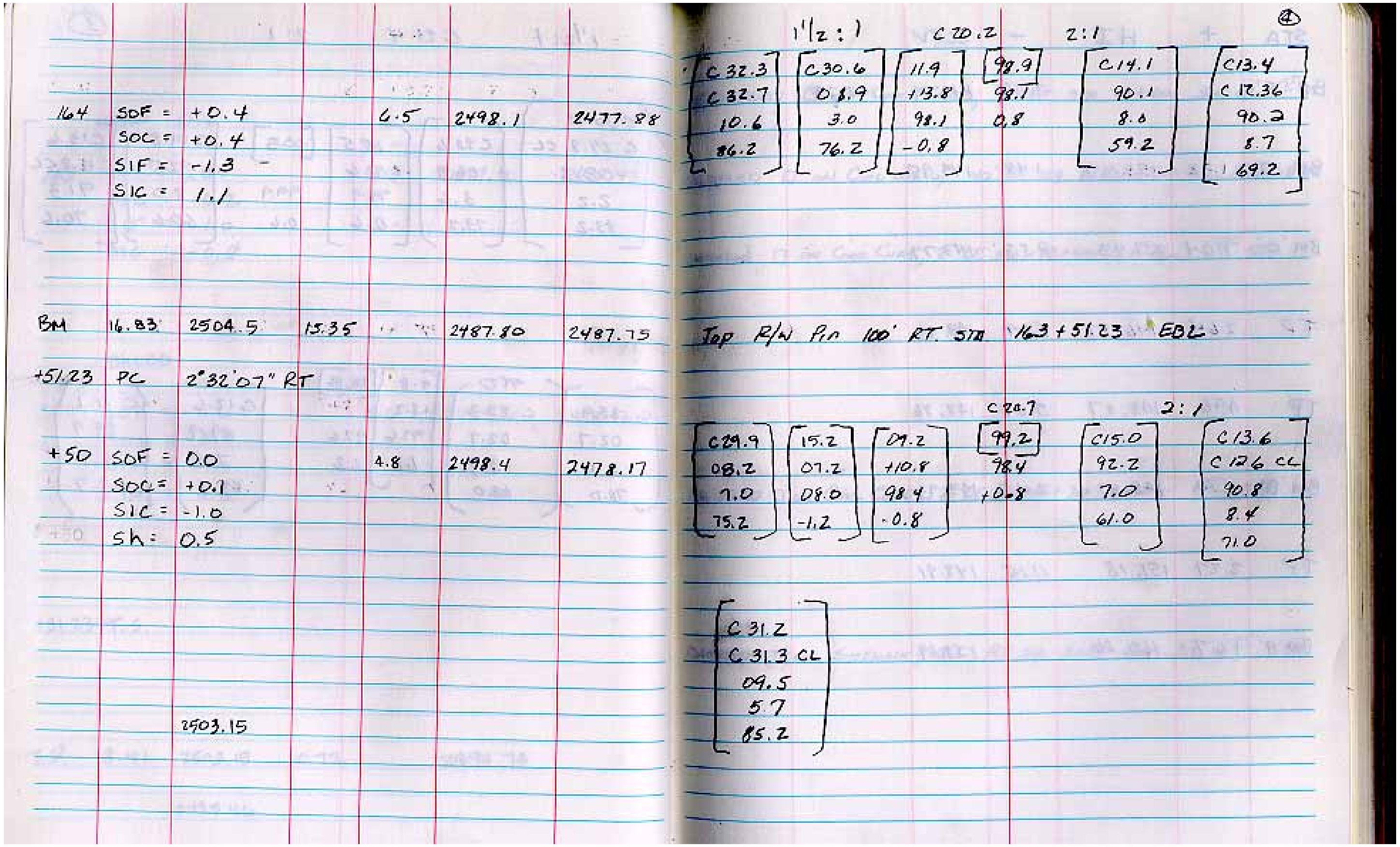
Hand Level (Locke)

NOTEKEEPING AND FIELD BOOKS

- Surveyors rely on their field notes for explaining their work in the field to people who may not have seen the project at all. Even with the use of digital data collectors, field books are utilized for sketches and recording of horizontal and vertical measurements. Standards vary between survey companies but on DOT projects there are established guidelines that need to be observed.

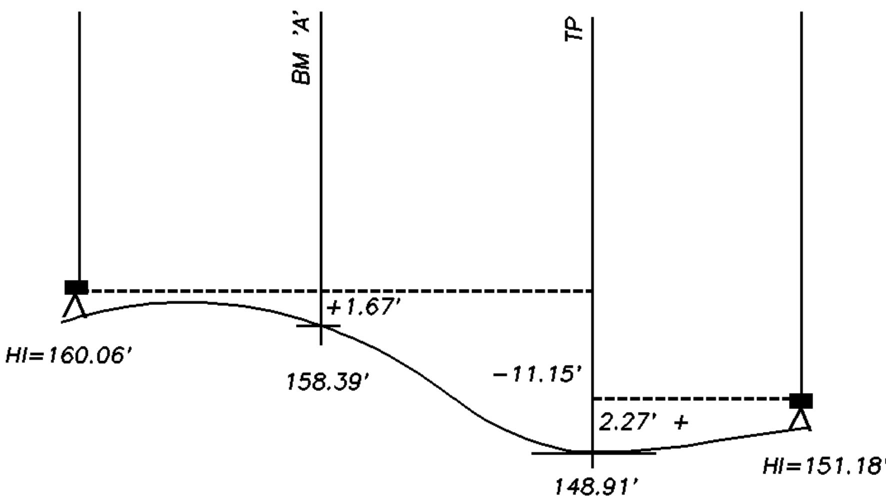


- Although, as an inspector, you may not be taking extensive field notes, it is important that you record the field observations and grade checks that you make while performing your duties. Your notes may be more important than you realize in the case of claims or discrepancies.



NOTEKEEPING AND FIELD BOOKS

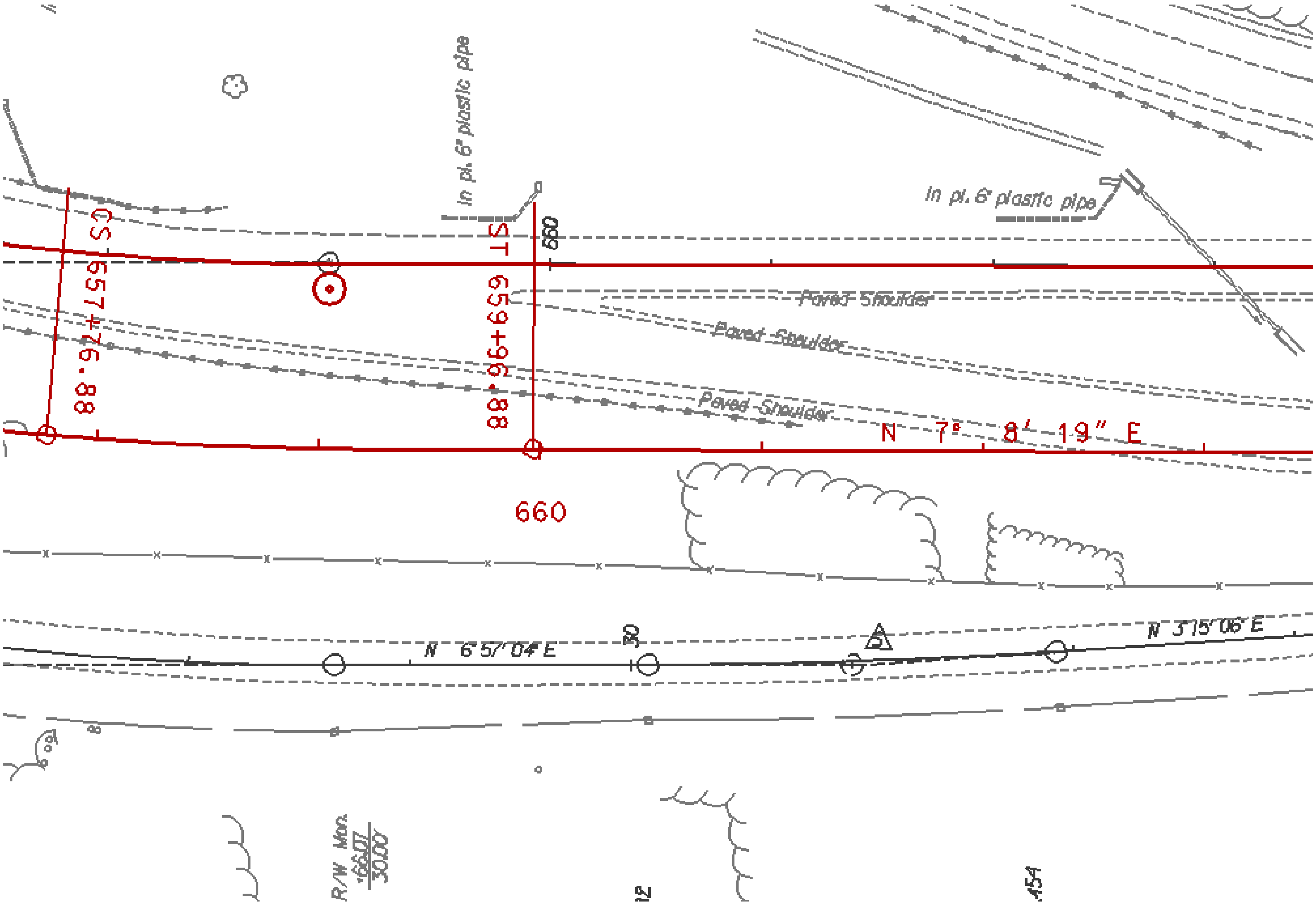
Differential Leveling Field Notes



STA	+	HI	−	ELEV	
BM 'E'			7.48	143.79	143.79
BM 'D'	1.32	151.27	1.48	149.95	
BM 'C'	7.64	151.43	2.58	143.79	
TP	2.64	146.37	5.09	143.73	
TP	4.96	148.87	5.01	143.86	
BM 'B'	5.14	148.87	7.45	143.73	
TP	2.27	151.18	11.15	148.91	
BM 'A'	1.67	160.06		158.39	

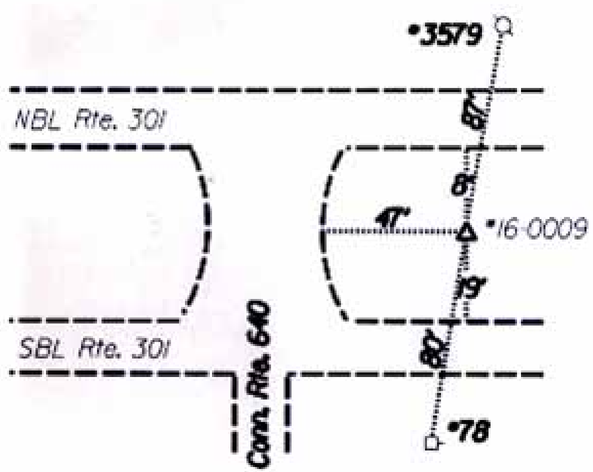
SURVEY DATA FROM PLANS

Construction Baseline



Survey Data Plan Sheets

- Review the information shown on the survey data sheets.
  - LD-200 (explain info shown without getting into details of coordinates, datum, etc.)
  - Benchmarks
  - Survey Alignments



Control ID no.16-0009
Route 207
Established by J. A. Stout
Vertical datum based on USC&GS 1929
Horizontal datum based on GPS

Project no.6207-016-107, C502
City/County Caroline
Year 1988
Elev 218.68'

Plane Coordinates
NAD 1983 Metric Values Zone
X (East)
Y (North)

Project Coordinates
X (East) 3,615,104.576
Y (North) 132,804.768

Azimuth to Station 16-0010 Is 2,412.92' 349°13'15"

Detailed description: A standard disk set in concrete stamped 16-0009. To reach the monument from the Courthouse in Bowling Green, proceed south on Rte. 2 for 1.8 mi. to the intersection with Rte. 640. The monument is located on the left in the median of the highway, 47' south of the crossover.

BENCH MARK REFERENCE:	Levels based on U.S.C.&G.S. 1929 datum	
B.M. Description:	B.M. Location:	Elev.:
RR spike in base 12" pine	75' Lt. 578+40 Sur. SBL 297 BL	160.67'
Corner of 1st conc. step to 1.5 SFD	275' Lt. 589+15 Sur. SBL 207 BL	180.88'
3 nails in base 12" twin oak	85' Lt. 599+80 Sur. SBL 207 BL	192.43'
3 nails in base 18" twin oak	65' Lt. 605+75 Sur. SBL 207 BL	149.99'
3 nails 3' up in side 12" gum	90' Lt. 610+75 Sur. SBL 207 BL	194.68'
Conc. monument on PL corner Old Mansion Property	70' Lt. 618+45 Sur. SBL 207 BL	205.59'
3 nails in base 18" poplar	125' Lt. 627+15 Sur. SBL 207 BL	174.98'
Iron pin on PL corner Old Mansion Property	85' Lt. 632+40 Sur. SBL 207 BL	201.07'
3 nails in base 18" hickory	65'	
3 nails in base 8" wild cherry on fence	65'	
Chiseled [] on stone step	35'	
Chiseled X on headwall of pipe under Rte. 301	162	
R/W mon. on fence	80'	
Nail with flagging in conc. slab entr. to frame shed	10C	

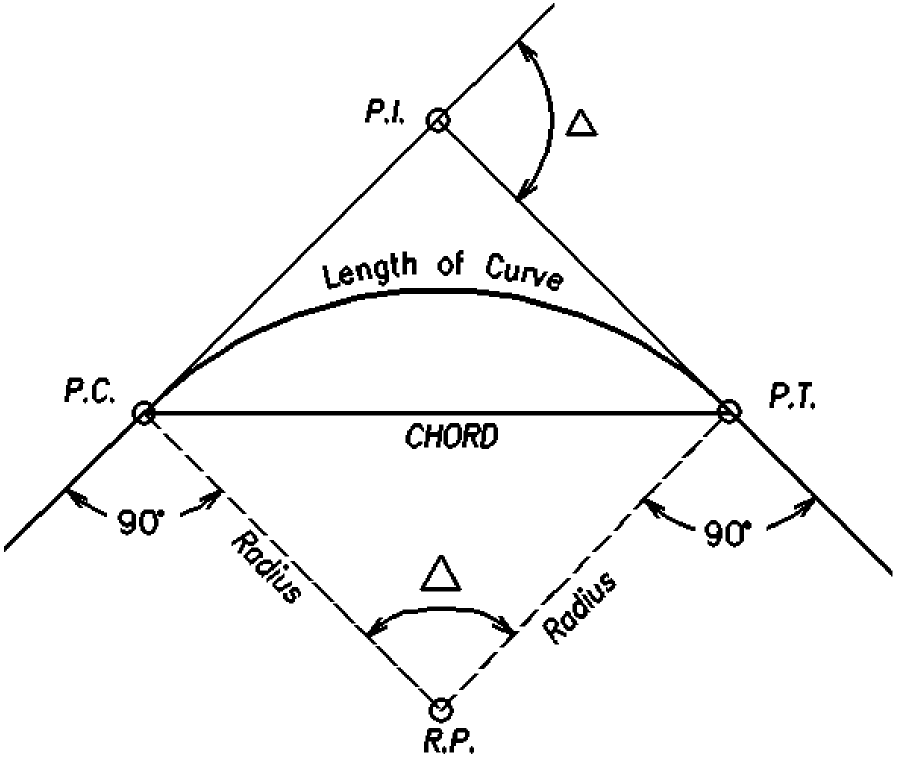
SURVEY ALIGNMENTS

POINT ID.	STATION	BEARING	PROJECT COORDINATES NORTH (Y)	EAST (X)
	SBL RTE 207			
SS	560+00.000		136,487.383	3,606,523.804
		N 50° 47' 53" E		
PC	577+26.045		137,578.339	3,607,861.356
PI	588+27.241		138,274.356	3,608,714.698
	Δ = 59° 56' 03" Rt.	D = 3.0000	T =	1,101.196'
	L = 1,997.806'		R =	1,909.859'
PT	597+23.850		137,884.532	3,609,744.585
		S 69° 16' 04" E		
PC	597+23.848		137,884.533	3,609,744.582
PI	600+32.541		137,775.255	3,610,033.286
	Δ = 27° 15' 23" Rt.	D = 4.5000	T =	308.693'
	L = 605.698'		R =	1,273.240'
PT	603+29.545		137,545.893	3,610,239.887
		S 42° 00' 41" E		
PC	603+79.519		137,508.762	3,610,273.333
PI	614+21.360		136,734.661	3,610,970.615
	Δ = 78° 35' 03" Lt.	D = 4.5000	T =	1,041.841'
	L = 1,746.316'		R =	1,273.240'
PT	621+25.834		137,264.932	3,611,867.412
		N 59° 24' 16" E		
PC	647+38.669		138,594.799	3,614,116.492
PI	653+63.330		138,912.736	3,614,654.188
	Δ = 52° 15' 57" Lt.	D = 4.5000	T =	624.661'
	L = 1,161.464'		R =	1,273.240'

Horizontal Curves

- The following components of a curve are identified for the purpose of understanding the stationing of the baseline.

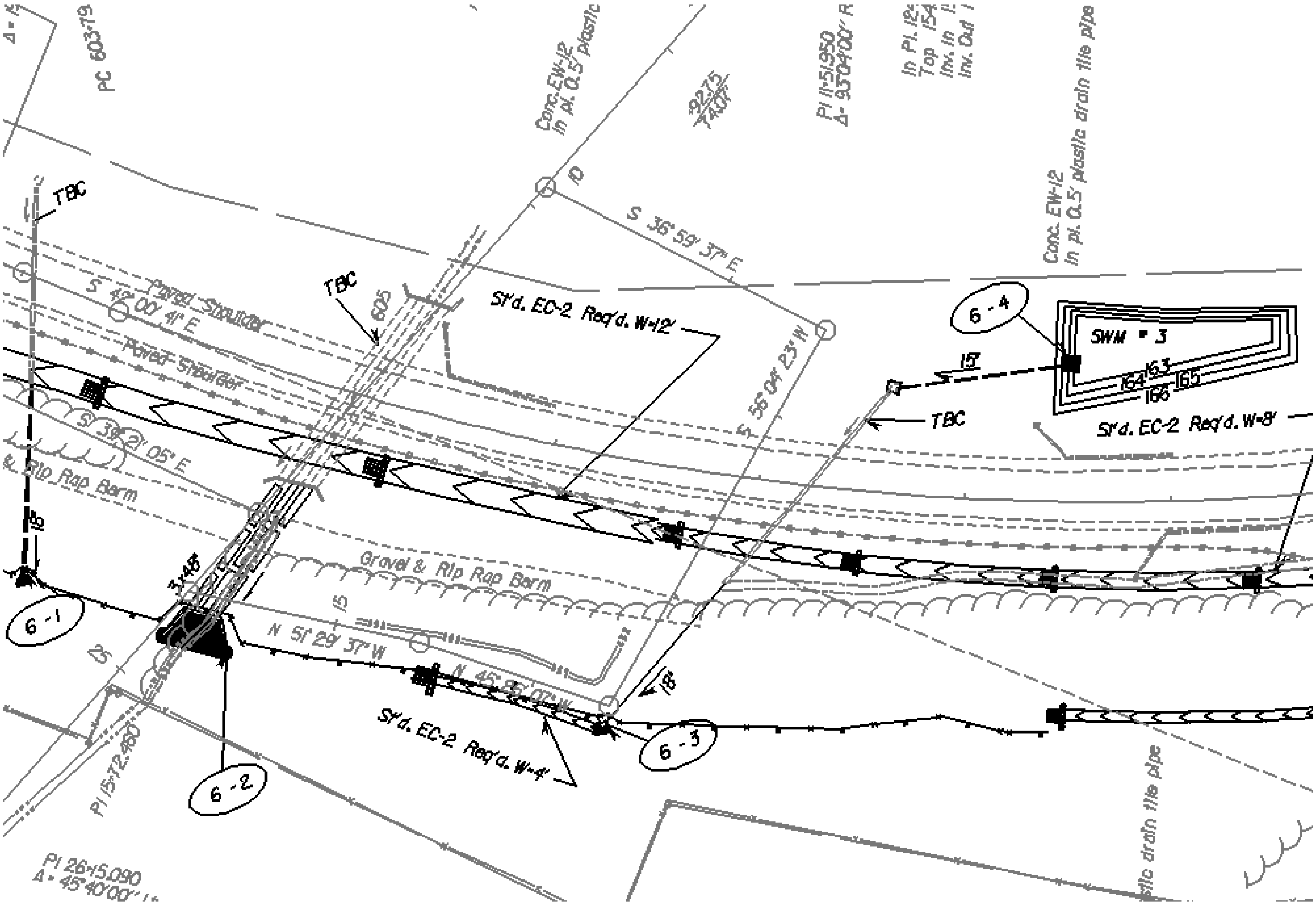
  - Point of Curvature (**PC**)- the beginning of the curve, tangent (90°).
  - Point of Intersection (**PI**)-where the two tangent lines meet.
  - Point of Tangency (**PT**)- the end of the curve, tangent (90°).
  - Radius Point (**RP**)- the center of the circular curve.
  - Delta or Central Angle (Δ)- the deflection angle at the PI and the angle between the radial line from the PC and PT.
  - Arc Length (**L**)- the length of the curve between the PC and PT, as measured along the curve.



P C. = POINT OF CURVATURE
P.I. = POINT OF INTERSECTION
P.T. = POINT OF TANGENCY
R.P. = RADIUS POINT

PLANS

Drainage Structures

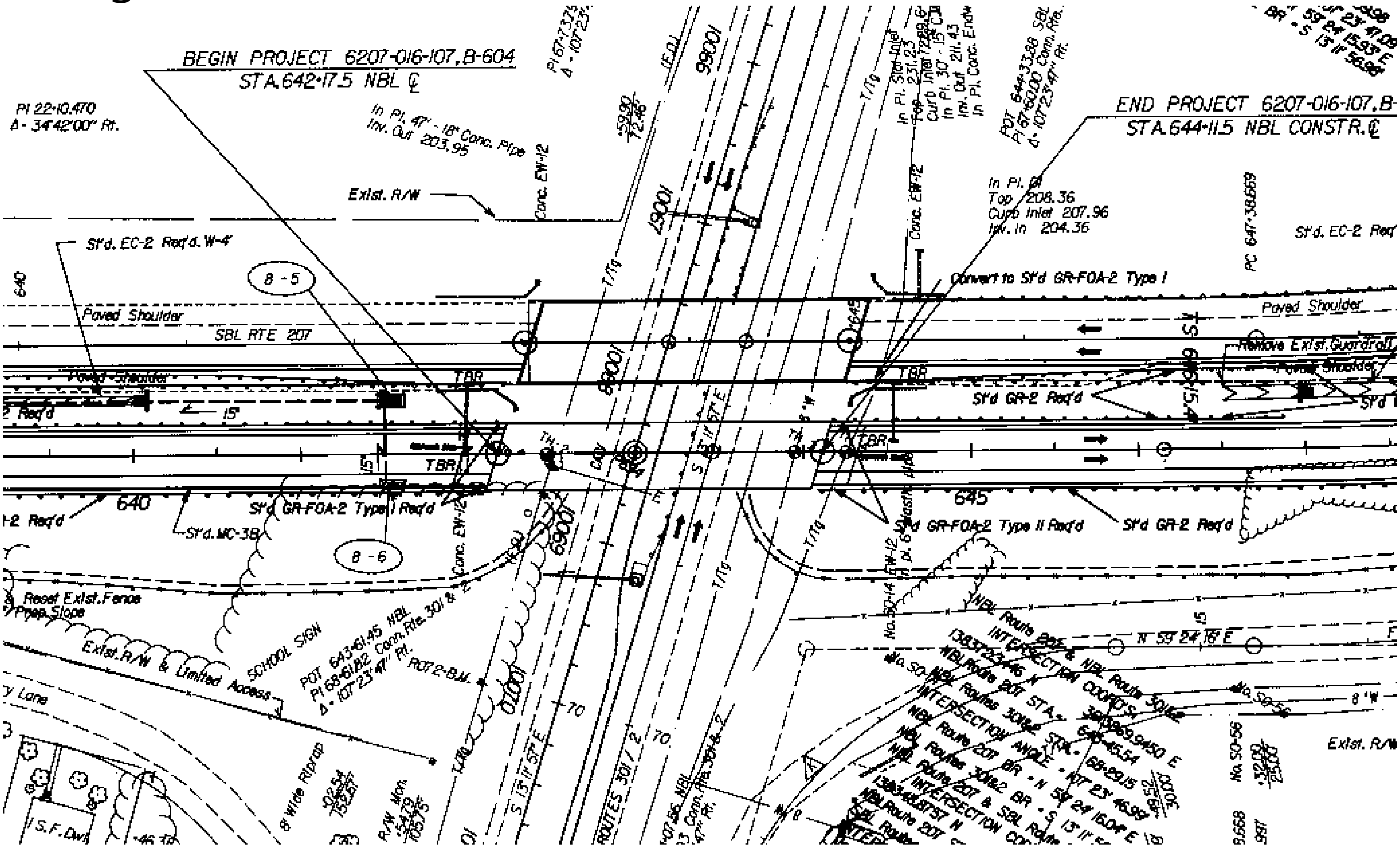


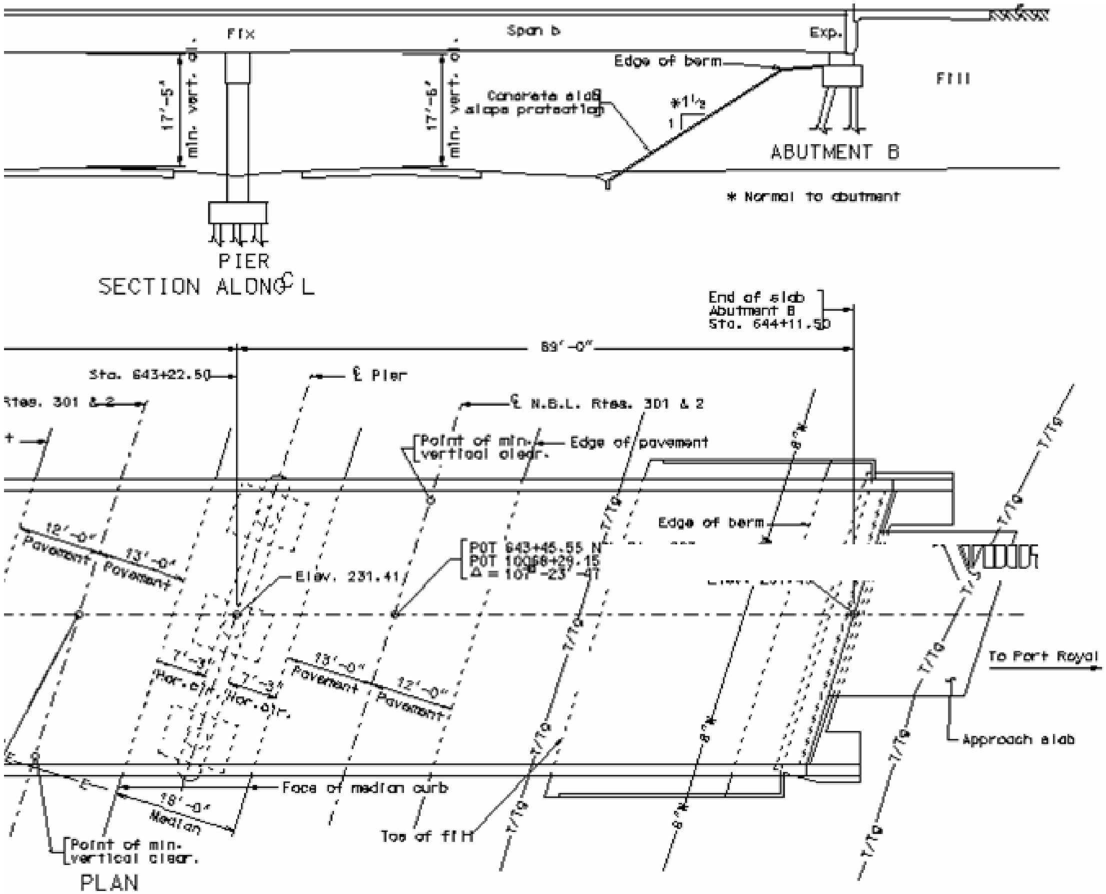
Drainage Structures

SHEET 6

6-1	90' - 18" Conc. Pipe Req'd. (13' cover) (Connect to Exist. 18" Pipe) Inv.(in) 150.00 Inv.(out) 149.00 1 - Std. ES-1 Req'd. 4 Tons Erosion Control Stone Class I Req'd. Std. EC-1 Placement
6-2	240' - 48" Conc. Pipe Req'd. (15' cover) (25° skew, Triple Line 80' Each) (Connect to Exist. 48" Pipes) Inv.(in) 145.50 Inv.(out) 143.30 Excavate 4' and Backfill with 437 Tons Erosion Control Stone Class AI 146 Tons Bedding Mat'l. Aggr. No. 25 or 26 510 C.Y. Minor Structure Excavation Req'd. 1 - Std. EW-7S Req'd. 65 Tons Erosion Control Stone Class I Req'd. Std. EC-1 Placement
6-3	88' - 18" Conc. Pipe Req'd. (15' cover) (Connect to Exist. 18" Pipe) Inv.(in) 150.64 Inv.(out) 149.86 1 - Std. ES-1 Req'd. 4 Tons Erosion Control Stone Class I Req'd. Std. EC-1 Placement
6-4 — Exist.	84' - 15" Conc. Pipe Req'd. (9' cover) Inv.(in) 156.00 Inv.(out) 151.79 (Connect to Exist. D.I.)
6-4	9.50 LF -Mod. Std. DI-7 Req'd. Type I Grate (Std. SWM-1, see sheet) Inv. 156.00 Inv. 3" Orifice - 163.00 362 C.Y. Siltation Control Excavation Req'd.

Bridges


BEGIN PROJECT 6207-016-107,B-604
STA.642+17.5 NBL ℄
END PROJECT 6207-016-107,B-
STA.644+11.5 NBL CONSTR.℄
PI 22+10.470
Δ = 34°42'00" Rt.
Exist. R/W
Std. EC-2 Req'd. W-4'
Paved Shoulder
SBL RTE 207
Convert to Std GR-FOA-2 Type I
Remove Exist. Guardrail
Std GR-2 Req'd
Std GR-FOA-2 Type I Req'd
Std GR-FOA-2 Type II Req'd
Std.MC-3B
SCHOOL SIGN
Exist.R/W & Limited Access
Reset Exist.Fence
8' Wide Riprap
TBR
B-5
B-6
640
645
N 59°24'16" E



Width: 40'-0" face-to-face of curbs.

Span Layout: 105'-89' continuous steel plate girder spans.

Capacity: HS20-44 loading and alternate military loading.

Specifications:

Construction: and Bridge Specifications, 1994.

Design: AASHTO Standard Specifications for Highway Br 1989; 1990 and 1991 Interim Specifications; an Modifications.

These plans are incomplete unless accompanied by the Supple Specifications and Special Provisions included in the contr documents.

Design loading includes 20 p.s.f. allowance for constructio tolerancesand construction methods.

Structural steel for girder webs and flanges including spl and filler plates shall be ASTM A709 Grade 50. All other st steel including diaphragms, cross frames, stiffeners, conne and bearings, including sole plates, shall be ASTM A709 Gra

Finish paint color shall be green, 595-24227.

Concrete in prestressed piles shall be Class A5. Concrete f superstructure, including parapets, integral backwalls and shall be Class A4; in abutments and pier Class A3.

Deformed reinforcing bars shall conform to ASTM A615, Grade bars in piles may be Grade 40. All reinforcing bar dimensio detailed drawings are to centers of bars except where other noted and are subject to fabrication and construction toler

Piles in abutments and pier have a design capacity of 42 to

Structural approach slabs are not included in the bridge co

B.M.: 3 nails in base 8" wild cherry on fence 65' Lt. Sta. Sur.℄L Elev. 208.79.

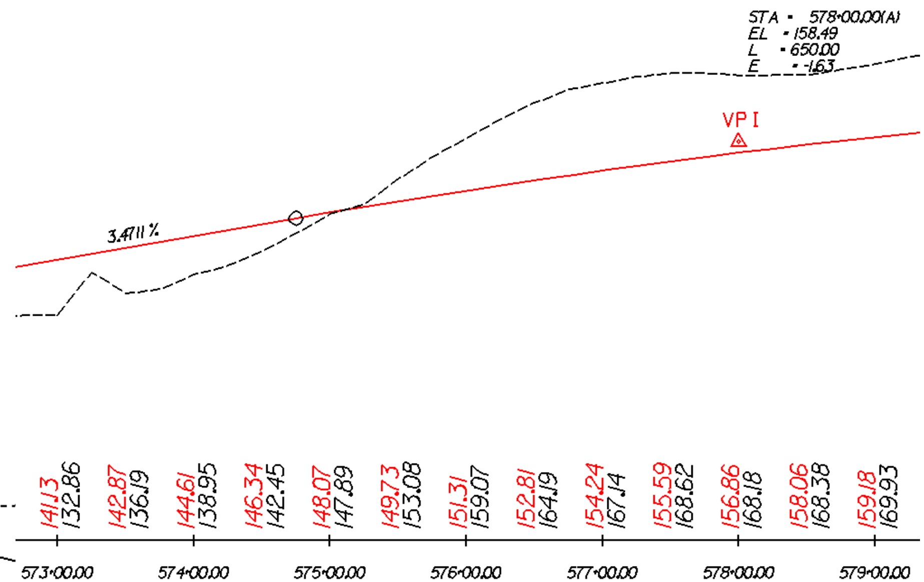
IMATED QUANTITIES

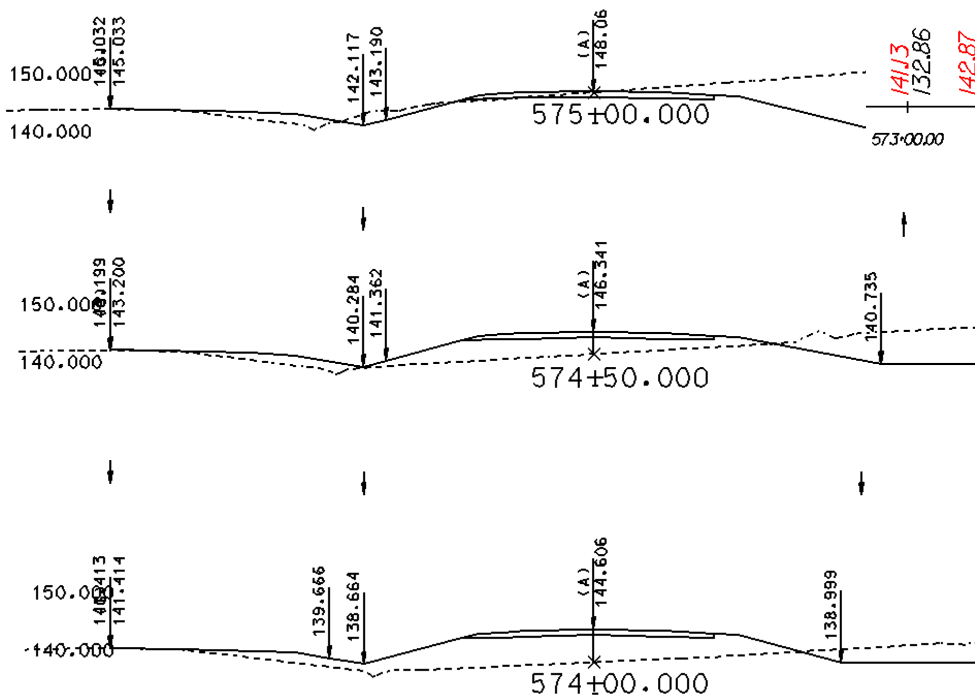
Concrete Parapet LF ⊕	Structure Excavation CY ⊕	Prestr. Conc. Piles 12" LF	Driving Test for 12" Prest. Conc. Piles LF	Dynamic Pile Test EA	Conc. Slab Slope Prot. 4" SY ⊕	Pipe Underdrain 6" LF	Porous Backfill CY ⊕	Br. Deck Grooving SY ⊕
390	—	—	—	—	—	—	—	862
21	—	—	—	—	—	—	—	—
—	71	1150	75	1	198	86	19	—
—	—	—	—	—	—	—	—	—
—	86	1760	60	—	—	—	—	—

PROPOSED BRIDGE ON
N.B.L. RTE. 207 OVER RTES. 301

Slope Staking

- In order to set slope stakes, you must be able to obtain certain information from the plans:
  - Existing centerline elevation
  - Proposed centerline elevations
  - Slopes (i.e. 2:1)





- This information can be found on the profile, cross sections and typical sections sheets.

CONSTRUCTION STAKEOUT

There are many items that need to be staked, for horizontal and vertical alignment, on any construction project. We will discuss a few of the more major items that you will need to be familiar with.

Construction Baseline

The construction baseline needs to be staked and referenced to facilitate the staking of the majority of the project.

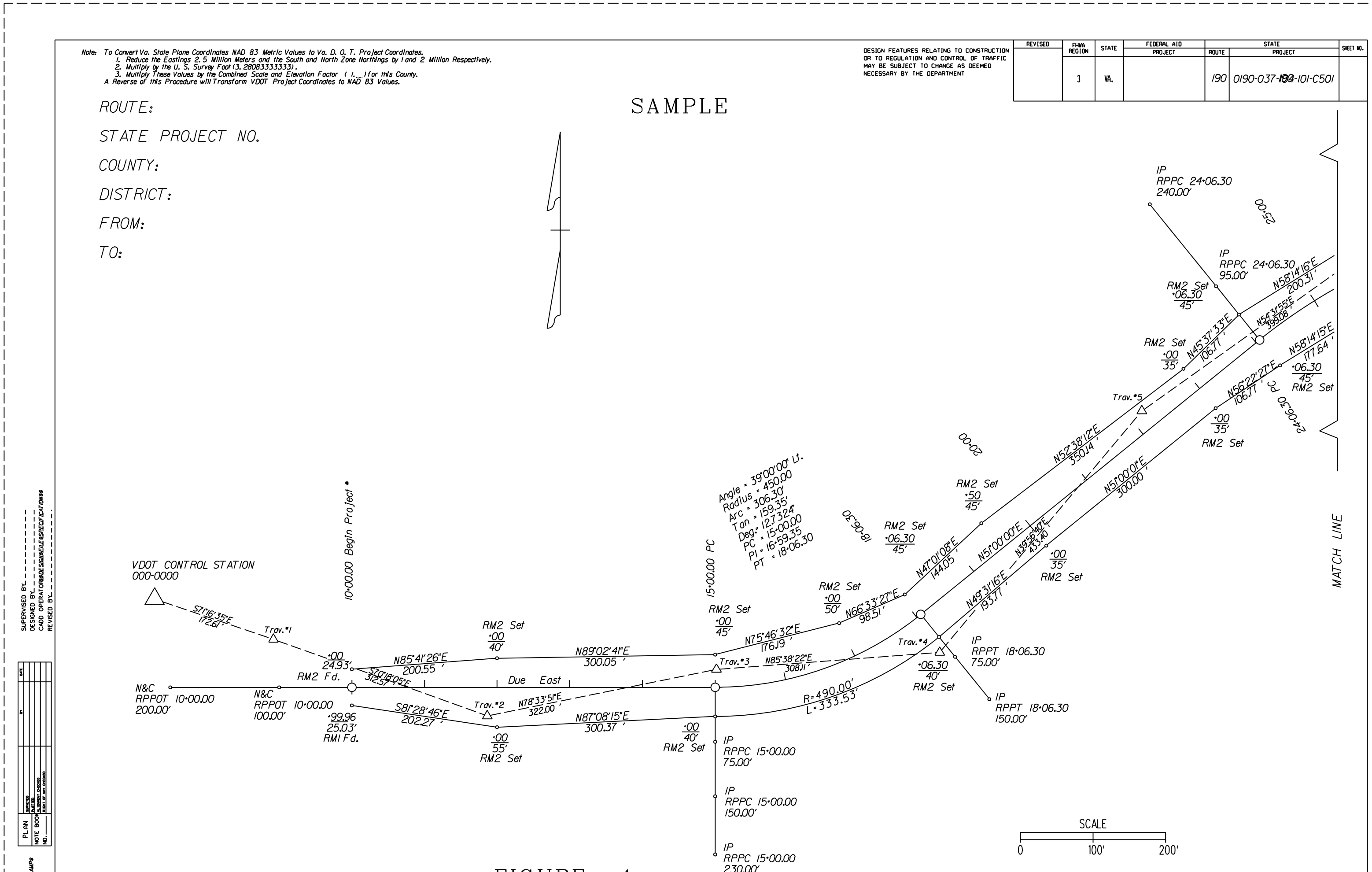


FIGURE 4

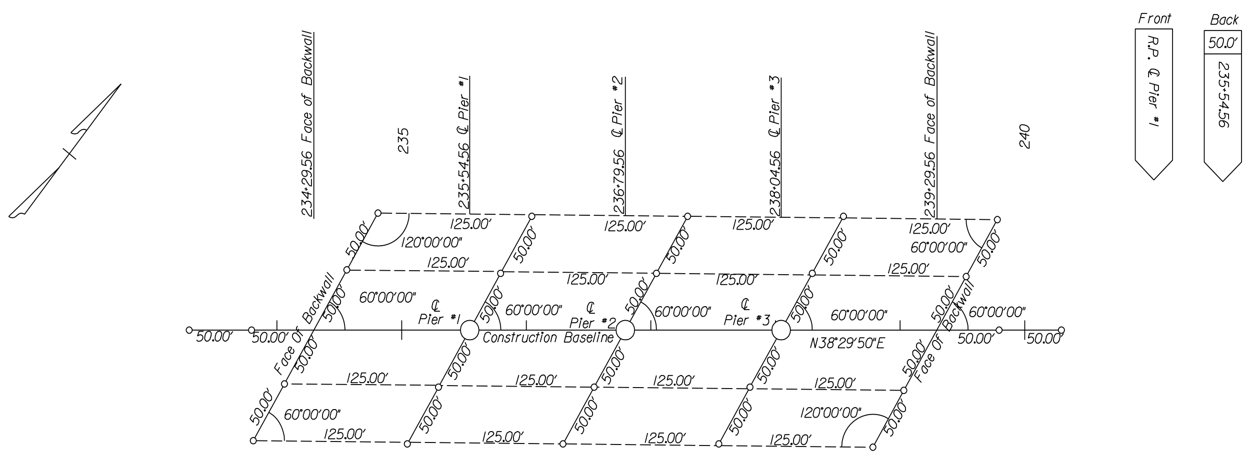
Bridges

Bridges must be staked to provide horizontal and vertical alignment of piers and abutment walls. Bridge work requires a high tolerance (accurate and precise measurements).

SAMPLE

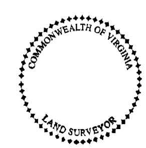
Benchmark #1 = 3 Nails Set In The Base Of A 36" Oak, 85' Lt.Of Sta.232+00 Construction Baseline
Elevation = 433.98

Benchmark #2 = Railroad Spike Set In The Top Of A 48" Stump, 105' Rt.Sta.240+50 Construction Baseline.
Elevation = 429.22



Note:

1. At Least Two Offset Points Shall Be Set On Each Side Of The Abutments And Piers.
2. Offsets When Possible Will Be Set Equal Distance From Backwall And Piers.
3. Angles And Distances Shall Be Checked At Ends Of All Offset Lines.
4. A Minimum Of Two Benchmarks Shall Be Set In The Immediate Vicinity Of The Bridge. The Descriptions And Station And Offset From The Construction Baseline Shall Be Shown On The Bridge Stake Out Sketch.
5. All Bridges Should Be Staked By One Field Crew And This Stake Out Verified By Another Field Crew Prior To Submittal Of This Sketch.
6. All Reestablishing Of Face Of Backwall And Centerlines Of Piers Will Be By Intersection Only. Distances Are Provided For Checking Purposes Only.



Certification

I,Licensed Land Surveyor,Hereby State The Stake Out Of Bridge #________,Project# _____________ Was Conducted Under My Direct Supervision And This Sketch Correctly Represents The Location Of All Offset Points Staked In The Field.

Land Surveyor *Reg.#* *Date*

FIGURE 3

CONSTRUCTION STAKEOUT

Drainage Structures

Drainage structures must be staked accurately to allow them to function as designed i.e. facilitate the flow of water.

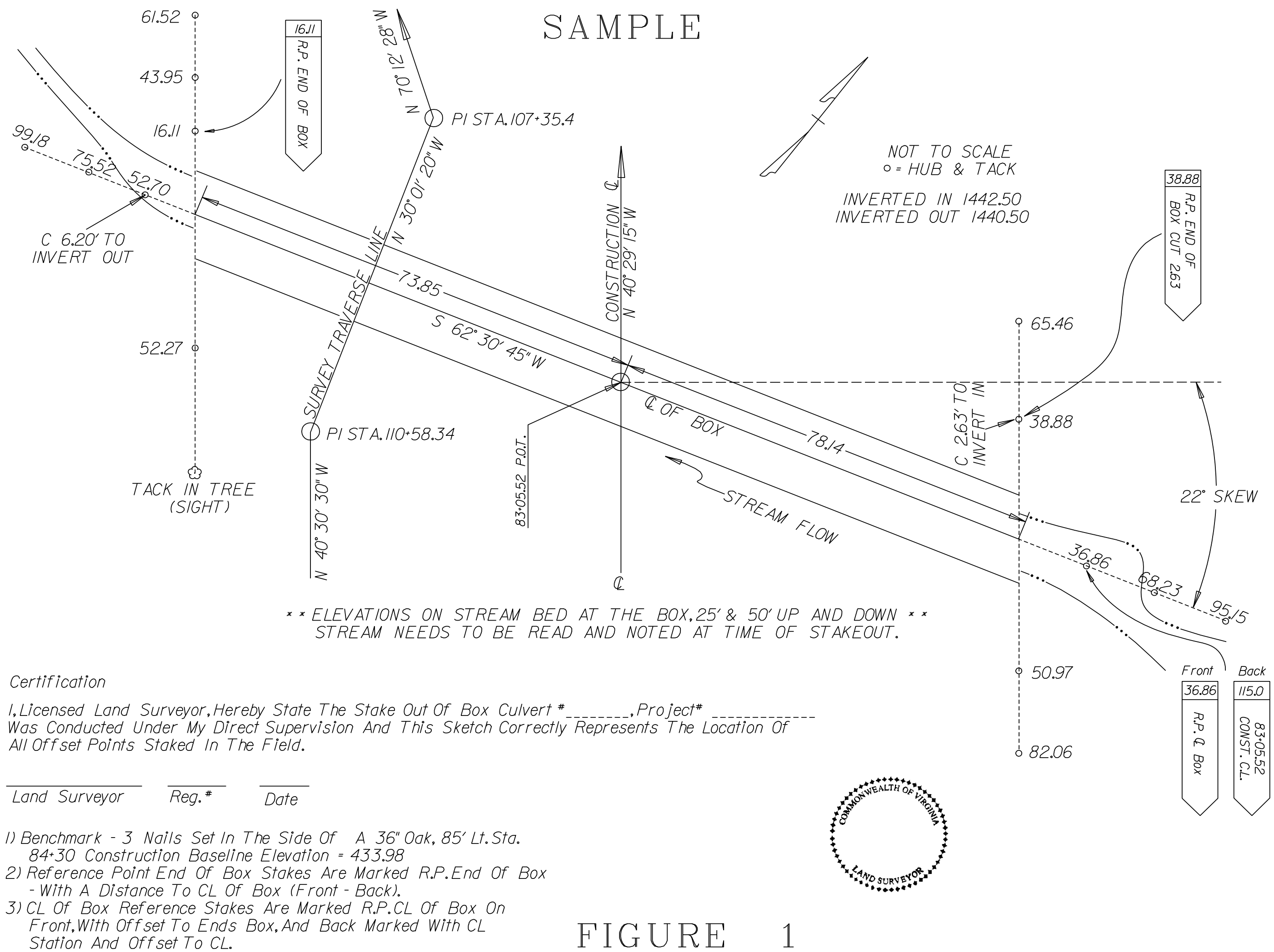
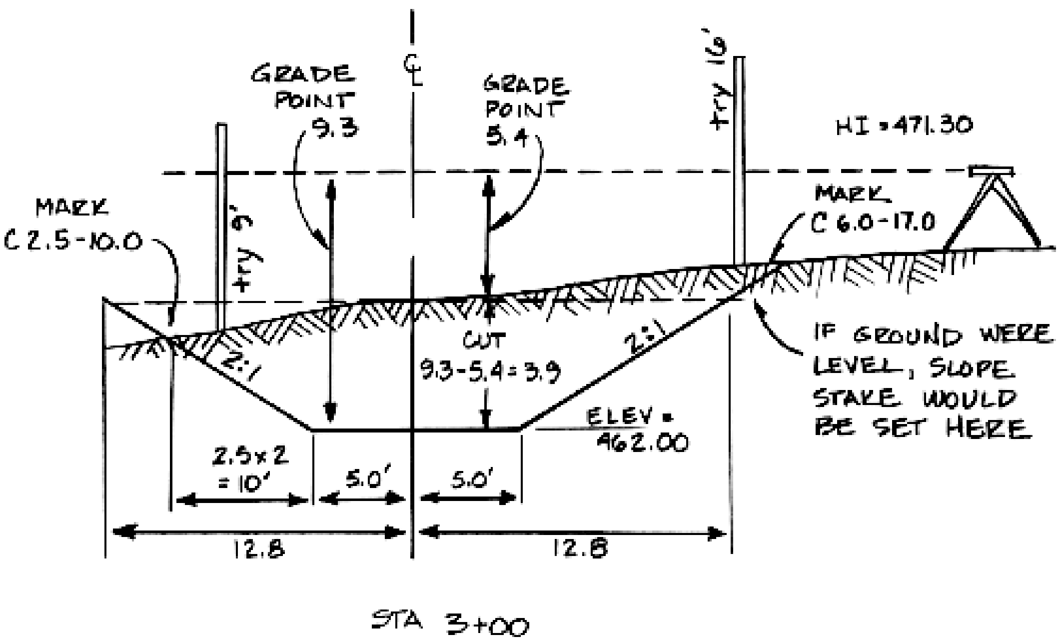


FIGURE 1

Slope Stakeout

- Slope stakes are set at all full and half stations. The correct method of setting slope stakes is shown on the attached figure. Before beginning slope staking it is necessary to examine the typical section and/or cross-sections to determine width of surfacing, width of shoulder and ditch, together with the cut/fill slopes. Also, a careful examination should be made of the summary sheets, plan sheets, profile sheets, and any special notes pertaining to the staking and construction of the project.



Slope Staking Example

Slope stakes are to be set at sta. 3+00. The bottom of the cut is to be at elevation 462.00 ft. and is 10 ft. wide. The side slopes are 2:1. (All measurements are in feet).

Solution

Step 1: Establish the level near sta. 3+00 and determine HI (471.30’ in this example).

Step 2: Compute the grade point by subtracting the elevation at the bottom of the cut from HI.

471.30’ – 462.00’ = 9.30’

Step 3: Determine the ground point by placing the rod on the ground at the centerline.

Step 4: Compute the cut at the centerline by subtracting the ground point from the grade rod.

9.3’ – 5.4’ = 3.9’

Step 5: Compute the distance to the left slope stake from the centerline as if the ground were level at this station.

5’ + (2)(3.9’) = 12.8’

Step 6: Note that the ground on the left slopes down and the side of the cut slopes up, indicating that the distance to the stake will be less than that for the level ground.

Step 7: Try a distance less than 12.8’, say 9.0’, and read rod at this distance. The rod reading is 6.6’.

Grade point – grade rod = 9.3’ – 6.6’

The distance computed from this rod reading is 5’ + (2)(2.7’) = 10.4’

Move toward 10.4’; try 10.0’ (Move less because slopes are opposite.)

Step 8: The ground point at the 10.0’ is 6.8’

9.3’ – 6.8’ = 2.5’

The computed distance is 5’ + (2)(2.5’) = 10.0’

The computed distance agrees with the measured distance.

Step 9: Set the stake at 10.0’ left of centerline and mark “C 2.5 @ 10.0” on top face of stake and “3+00” on bottom.

Step 10: Move to the right side. Try a distance greater than that for the level ground because the ground and sides both slope up.

Step 11: Try 16.0, the ground point is 3.4’.

9.3’ – 3.4’ = 5.9’

5’ + (2)(5.9’) = 16.8’

Step 12: Try 17.0’. Move beyond 16.8’ because the slopes are in the same direction. The ground rod is 3.3’.

9.3’ – 3.3’ = 6.0’

5’ + (2)(6.0’) = 17.0’

Step 13: Set the stake at 17.0’. Mark “C 6.0 @ 17.0”

Fine Grade stakes

- Fine grade stakes are to be set when the cuts and fills are complete and the roadway sub-grade is near grade.

  - On tangent alignments, the fine grade hubs are to be set on one side of the roadway, with distance and grade referenced to the centerline finished grade.
  - On curves, fine grade hubs may be required on both sides with offset and grade to the edge of pavement.
  - If the roadway has curb and gutter, hubs will be set on both sides of roadway with offset and grade to the top back of curb.